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(54) Injection molded plastic article with integral weatherable pigmented film surface.

(57) Molded articles (20) having contoured, decorative outer surfaces are disclosed. The articles (20) comprise a molded polymer substrate (21) and a decorative sheet material (10) adhered to one side of the substrate (21). The decorative sheet material (10) comprises a substantially molecularly unoriented cast polymer film (13) formed from a weatherable polymer. The articles (20) are particularly suited for use as automobile body panels and the like. Also disclosed is a method for making such articles (20), and a method for making sets of such articles (20) for assembly into automobile bodies and the like.

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INJECTION MOLDED PLASTIC ARTICLE WITH INTEGRAL WEATHERABLE PIGMENTED FILM SURFACE

Field of the Invention

This invention relates to shaped molded polymer articles generally, and particularly relates to shaped articles formed from a molded polymer substrate which have a decorative sheet material adhered to the outer surface thereof.

Background of the Invention

The trend in the automobile industry is towards increased use of plastic body panels in automobile construction. Use of such panels permits the weight of automobiles to be decreased, tooling costs arising from body styling changes to be decreased, and styling freedom in car design to be increased. Other advantages arising from this type of construction include reduced facility costs and factory floor space requirements, and process cycle times allowing the just-in-time, low inventory manufacturing of parts at or near the automobile assembly plant. See C. Kirkland and P. Dickard, Dateline: Detroit. SAE Show News Bulletins, Plastic Technology, page 103 (April 1986).

A significant problem with plastic automobile body parts is that many of the most desirable molding polymers for such parts are not weatherable. Moreover, many such polymers do not provide a good bonding surface for paints. Even where paint bonding problems are overcome, conventional spray-painting techniques pose a significant pollution problem arising from the evaporation of noxious paint solvents, and, further, are very expensive if a high quality, multiple coat paint finish is to be obtained. Because the overall finished appearance of an automobile is among its most important selling features, these problems are serious, and a great deal of effort and expense are being devoted to their solution. See , e.g., Automotive Coatings: Helping Detroit Woo Consumers, Chemical Week, page 30, (July 4, 1984).

Various molded polymer automobile parts with film surfaces have been made in the past. For example, clear, unpigmented, nonweatherable, cast PVC films have been used to surface interior automobile parts. Another example, U.S. Patent No. 3,679,510 to Conley and Ellison, discloses a reverse-printed, oriented, polyvinyl fluoride film bonded to a molded polymer substrat . Such weatherable, oriented films are excell nt for use in making side rails and other automobile trim parts. These films are, however, difficult to uniformly internally pigment--particularly when th film must provide the sam high-quality decorative app arance as a painted automobile body panel--and are generally not suitable for use in a deep draw molding procedure. See also U.S. Patent No. 4,369,157 to Connor.

Accordingly, an object of the present invention is to provide a molded polymer article which has a weatherable surface.

A further object of the invention is to provide an article as described above which has a high grade decorative finish suitable for use as an automobile body part.

An additional object of the invention is to provide an article of the type described which can be deep draw molded into various three-dimensional shapes used in automobile body parts.

Summary of the Invention

These and other objects and advantages of the present invention are achieved in the embodiments illustrated herein by the provision of an article having a contoured, decorative outer surface. The article is comprised of a molded polymer substrate and a decorative sheet material adhered to one side of the substrate and conforming to the contoured surface. The decorative sheet material comprises a substantially molecularly unoriented cast polymer film formed from a weatherable polymer, which film has pigments, such as colored pigments or reflective flakes, uniformly distributed therein.

Use of a cast polymer film facilitates the uniform distribution of the pigments within the film and enables the production of a high-quality decorative sheet material with an appearance suitable for use on an automobile body panel. Such pigmented, cast, weatherable films are suitable for deep draw molding, as will be explained below, and do not require the use of separate pigment layers in addition to a protective weatherable outer layer. While cast films do not have as great a tear strength as oriented films, this characteristic can be turned to an advantage in practicing the present invention, as will be explained below.

A shaped article as described above is made by placing into a mold having a contoured, three-dimensional molding surface, a preformed decorative sheet material of the type described above. A moldable polymer is then introduced into the mold on one side of th sheet material. The sheet material is then molded into a contoured threedimensional configuration conforming to the

molding surface of said mold, while molding said polymer to form a shaped article with the decorative sheet material adhered to the outer surface thereof.

Preferably, the decorative sheet material also includes a bonding layer formed of a polymer different from the cast film, wherein the decorative sheet material is placed into the mold with the bonding layer oriented inwardly away from the molding surface so as to become adhered to the moldable polymer.

Also disclosed herein is a method of making a structure such as an automobile body which has a uniform decorative outer surface, which is comprised of a set of interconnected shaped articles formed from a molded polymer material (and optionally from a plurality of different moldable polymer materials), and a method of making a set of articles for assembly into such a structure. Each article in the set is preferably formed of a moldable polymer which is selected to provide the desired structural properties to the particular location in the assembled structure in which it is installed. At the same time, while the assembled structure may be formed from different structural polymer materials, it has an outer surface which is uniformly colored in accordance with a predetermined color scheme (single colored, multicolored, etc.). This method comprises the steps of first placing into a mold a preformed decorative sheet material of the type described above, then introducing a moldable polymer into the mold as described above, and then molding the sheet material and the polymer, as also described above. These three steps (placing sheet material into mold; introducing polymer into mold; molding sheet material and polymer) are then repeated for each article in the set, so that each article in the set has the same weatherable cast pigmented polymer film on the outer surface thereof. As stated above, the articles in the set may or may not all be formed of the same moldable material. Therefore, for the making of each article, the decorative sheet material has a bonding layer of a material which has been preselected to adhere to the particular moldable polymer from which that particular article is made. While molding polymers may thus advantageously differ from article to article, and bonding layers may accordingly differ from article to article, every article in the set has the same cast pigmented film on the outer surface thereof. As a result, when the set of molded articles is assembled into the aforesaid structure, the need for spray-painting the structure to otherwise provide it with a uniform decorative outer surface is eliminated.

Brief Description of the Drawings

Figure 1 is a schematic illustration of an apparatus and procedur for making molded plastic articles of the present invention.

Figure 2 is a cross-section of a decorative film, taken along the line 2-2 of Figure 1.

Figure 3 is a perspective view of an automobile formed from a set of molded plastic articles of the present invention.

Figure 4 is an exploded view of a set of molded plastic articles of the present invention.

Figure 5 is a cross-section of a molded plastic article taken along the line 5-5 of Figure 4.

Detailed Description of the Invention

Molded plastic articles of the present invention can be made by placing a preformed decorative sheet material 10 into a mold 11, closing the mold, and injecting a moldable polymer 12 into the mold on the inner side of the film 10 (see Figure 1). Th decorative sheet material, as shown in Figure 2, comprises a substantially molecularly unoriented weatherable cast film 13 which has pigments uniformly distributed therein, and a bonding layer 14 formed of a different polymer adhered to the inner side of the cast film.

Molded plastic articles 20 of the present invention are particularly suitable for use as outer body panels in an automobile, as illustrated in Figure 3. Such an automobile has a body which is comprised of a set of molded plastic articles 20, as illustrated in Figure 4. Figure 5 illustrates a cross section of a molded plastic article of the present invention, with the preformed decorative sheet material 10 adhered to the molded polymer substrate 21. Figure 5 shows that the bonding layer 14 is adhered to the molded polymer substrate 21, with the weatherable cast film on the outer surface of the article.

Cast films for practicing the present invention should be selected so they are pigmentable, th rmoformable and weatherable. Such films are substantially molecularly unoriented cast films, as opposed to films which have been oriented or biaxially oriented. The films are "preformed" films, in that they are provided as self-supporting sheets of material. Such films are prepared by a number of known liquid casting methods, such as by spreading a solvent solution having a polymer dissolved therein onto a carrier with a casting die, doctor bar, or reverse roll coater, th n evaporating the solvent, and then stripping the polymer film from the carrier. The reverse-roll coating method is th preferred method of making liquid cast films for the present invention. Other liquid casting methods ar

also known and useful for practicing the present invention. In appropriate cases, a plastisol, organosol, or dispersion of the polymer can be cast onto the carri r instead of a solvent solution. For example, polytetrafluoroethylene, which is virtually insoluble, can be cast as a dispersion. Such liquid cast film processes, and some current uses of cast films, are discussed in Plastics Engineering, at pages 29-33 (May, 1983). Thus, for purposes of the present invention, "substantially molecularly unoriented cast films" are liquid cast films, and not melt cast films or films formed by extrusion.

Colored pigments are uniformly distributed in the cast film by dispersing them in a vehicle compatible with the liquid from which the film is cast, and mixing the vehicle with the same prior to casting the film. Preferably, reflective flake pigments, such as aluminum flakes of the type used to produce metallic finishes on automobiles, or mica flakes, either surface treated (e.g., pigmented) or not, of the type used in automobile finishes, are uniformly distributed in the cast film in like manner. U.V. screeners are added as needed to improve the weatherability of the cast films.

Polymers suitable for forming such weatherable cast films are selected to provide a pigmented film which will not significantly fade, peel, chalk, or crack, when exposed to the environment, for the intended life of the product for which the molded plastic article is made. A number of known testing procedures, in which objects are exposed to either the natural environment over an extended time or a harsh artificial environment for a short time, are used to determine the weatherability of polymers. Such weatherable polymers include fluoropolymers, acrylate polymers, urethane polymers, and blends thereof. Acrylate polymers useful for practicing the present invention are obtained from a variety of acrylic monomers, such as acrylic and methacrylic acids, and their amides, esters, salts, and corresponding nitriles. Particularly suitable monomers for such polymers are methyl methacrylate, ethyl acrylate, and acrylonitrile. The polymers may each be used in the form of homopolymers, or with various other monomers which can be copolymerized therewith. Additional illustrative examples of acrylate polymers which may be useful for the present invention are thermoplastic polyacrylates and polymethacrylates which are homopolymers and copolymers of acrylic acid ester and methacrylic acid ester, such as, for example, polyacrylic acid isobutyl ester, polymethacrylic acid methyl ester, polymethacrylic acid ethylhexyl ester, polyacrylic acid ethyl ester; copolymers of various acrylic acid esters and/or methacrylic acid esters, such as, for example, methacrylic acid methyl ester/acrylic acid cyclohexyl ester copolymers; and copolymers of acrylic acid esters and/or methacrylic acid esters with styrene and/or alpha-methylstyrene, as well as the graft polymers and copolymers and polymer mixtures composed of acrylic esters, methacrylic acid esters, styrene and butadiene. A group of transparent, weath rable blends of acrylate polymers and polyvinylidene fluoride polymers useful for practicing the present invention are disclosed in U.S. Patent No. 3,524,906. The disclosures of this patent, and all other patent references cited herein, are specifically intended to be incorporated herein by reference.

Fluoropolymers useful for practicing the present invention include polymers and copolymers formed from trifluoroethylene, tetrafluoroethylene, hexafluoropropylene, monochlorotrifluoroethylene and dichlorodifluoroethylene. Copolymers of these monomers formed from fluoroolefins such as vinylidene fluoride are also useful. Further illustrative examples of fluoropolymers useful for practicing the present invention include polyvinyl fluoride and polyvinylidene fluoride. The fluoropolymer may be a fluorinated ethylene/propylene copolymer, or a copolymer of ethylene/chlorotrifluoroethylene. Vinylidene fluoride/hexafluoropropene and vinylidene fluoride/perfluoro (alkyl vinyl ether) dipolymers and terpolymers with tetrafluoroethylene are additional illustrative fluoropolymers useful for practicing the present invention.

A preferred weatherable polymer for use in the present invention is an alloy of an acrylic polymer and polyvinylidene fluoride, such as "FLUOREX" (a trademark of Rexham Corporation).

Urethane polymers useful for practicing the present invention are prepared by reacting a polyisocyanate with a compound containing at least two active hydrogen atoms, such as a polyol, a polyamine, or a polyisocyanate. Polyurethane resins for use in the present invention should be selected from resins in which the reactants have been chosen to provide weatherable, thermoformable polymers. Numerous suitable polyurethane resins useful for practicing the present invention are available. Generally, aromatic polyisocyanates tend to yellow, and aliphatic polyisocyanates are more preferred. Particularly noteworthy recent developments in this area are disclosed in U.S. Patent No. 4,578,426 (disclosing resins which give coatings resistant to gasoline and having high flexibility, scratch resistance and weather resistance) and U.S. Patent No. 4,501,852 (disclosing chemical resistant, abrasion resistant, elastic and durable polyurethanes).

The molded polymer substrat should be selected to provide engin ering prop rties (rigidity, etc.) suited to the specific end use of the particular article made. Such polymers are well known. Suit-

able polymers for the molded polymer substrate include, for example, polyvinyl chloride, polycarbonate, polystyrene, acrylonitrile-butadiene styrene, polyethylene, polypropyl ne, polyethylene terephthalate-glycol, nylon, and RIM urethanes. Polyolefin homopolymers and copolymers (ionomers, etc.) are inexpensive thermoplastic resins which have excellent molding properties and are particularly preferred for practicing the present invention. Polypropylene, for example, when glass filled and foamed with a blowing agent, has performance properties suitable for structural or engineering uses. Acid copolymers of polyethylene such as "SURLYN" (a trademark of E.I. Du Pont De Nemours) are similar in performance and in addition have exceptional toughness.

The bonding layer of the decorative film comprises a polymer coating applied to the inner surface of the cast polymer film. In a preferred embodiment, the bonding layer comprises a preformed film laminated to the inner surface of the cast film. Bonding of the decorative sheet to a polyolefin molded polymer substrate can be achieved with an intermediate bonding layer or layers in accordance with known laminating procedures, and with known adhesives. For example, a decorative sheet material of a cast polymer film layer which is bonded to or coated with a fusible olefin layer can be placed in a mold during injection of an olefin resin. Another approach is to bond a PVC film to a weatherable fluoropolymer film with an acrylic adhesive and, in turn, bond the PVC film to an olefin film with a polyester isocyanate adhesive. The cast film may also be laminated to an olefin film with a permanent type acrylic pressure-sensitive adhesive. Still another approach is to coat the cast film with a soluble olefin resin which adheres to the surfacing film and bonds to the injected resin without having or requiring an olefin film layer. Such a resin is chlorinated polyolefin 343-1 from Eastman Kodak. This resin may be used in conjunction with an acrylic primer or ingredient to bond to desired fluorocarbon films. Corona treatment of the olefin surface to be bonded to the cast film may optionally be used to achieve an optimum bond. Bonding may also be improved by surface treating the cast film, as by corona treatment.

Preferably, the tear strength of the cast film is less than the bond strength of the cast film to the molded polymer substrate. This will prevent tears from forming in the cast film, running across the surface of the molded article, and quickly destroying the article. Instead, the weatherable cast polymer film surface will flake off in small particles when disrupt d by nicks and scratches from stones and other flying particles, as routinely confronts automobile surfaces. The inner bonding layer may be from about .25 to about 250 thousandths of an inch thick, with a thicker bonding layer pref rred to secure the w atherable film to larger articles. The bonding layer need not be formed of a cast film, as long as it is sufficiently thermoformable. The cast weatherable film is preferably between .5 and 300 thousandths of an inch thick, and most preferably from about one to about two thousandths of an inch thick. Similar molded parts can be achieved with injected ABS and styrene by laminating the surface film to a corresponding substrate layer of ABS or styrene.

The present invention is carried out on conventional molding equipment in accordance with known techniques. Particularly suitable injection-molding equipment and techniques are disclosed in U.S. Patent Nos. 4,397,806 and 4,307,057 to Hettinga. The decorative film may be heated and vacuum formed in a separate forming mold prior to being placed in the injection mold, or may be shaped by heat and pressure in the injection mold.

The present invention is particularly suitabl for making deep draw molded articles. Deep draw articles, and deep draw molding procedures, ar those in which the depth of the molded articl is relatively large in relation to the length and width of the two-dimensional decorative sheet material from which the article is made. More particularly, the depth of the article should be such that substantial stretching and elongation of the decorative sheet material occurs at least in regions of the decorative sheet material. Such substantial stretching and elongation occur when the decorative sheet material is subjected to elongation of about 25% or more at least in regions thereof. The cast film is preferably formed from a polymer selected so that the decorative sheet material will maintain a paint-like appearance, and will not stress whiten, when stretched and elongated.

The present invention is explained further in the following nonlimiting examples.

Example 1

A weatherable cast film formed from an alloy of an acrylic polymer and polyvinylidene fluoride, is formed with internal pigments, including reflective metallic flakes. The film is laminated to a polyvinyl-chloride (PVC) film with an acrylic adhesive. The multilayered film is then placed in a mold, the mold closed, and PVC injected into the mold behind the polyvinlychloride bonding layer. The PVC molding polymer and the weatherable film/PVC film laminate are th n molded for a time and temp rature sufficient to form a shaped articl , with the weatherable film bonded to th outer surface thereof by the PVC bonding layer.

Example 2

The procedure of Example 1 is repeated with polyethylene terephthalate-glycol (PETG) as the bonding substrat and with PETG as the molding polymer to form additional molded articles.

Example 3

The same procedure is carried out as described in Example 1 above, except that the cast film is bonded to a PETG bonding film, and urethane is used as the molding resin.

Example 4

The same procedure is carried out as described in Example 1 above, except that the cast film is bonded to an acrylonitrile butadiene styrene (ABS) bonding film, and ABS is used as the injection-molding polymer.

Example 5

A weatherable cast film formed from an alloy of an acrylic polymer and polyvinylidene fluoride is bonded to a PVC film with an acrylic adhesive, and the PVC film is bonded to a polypropylene film bonding layer with a polyester isocyanate adhesive. An article is made according to the procedures set forth in Example 1, with polypropylene as the molding polymer. Other articles can be made with other olefins as bonding layers, and with thermoplastic olefins, known as "TPO polymers," as molding polymers.

Example 6

A weatherable cast film formed from a fluoropolymer, an acrylate polymer, a urethane polymer, or a blend thereof, is bonded, with an acrylate adhesive, to an ABS, PVC, or nylon film to form a decorative sheet material. Articles are made with such decorative sheet materials according to the procedures set forth in Example 1, with nylon molding polymers.

In the drawings and specification, there has been disclosed typical preferred embodiments of the invention. Although specific terms are employ d, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in th following claims.

Claims

1. A shaped article (20) having a contoured decorative outer surface, comprising a molded polymer substrate (21) and a decorative sh et material (10) adhered to one side of said substrate (21) and conforming to said contoured surfac , characterized in that said decorative sheet material (10) comprises a substantially molecularly unoriented cast weatherable polymer film (13), said cast polymer film (13) having pigments uniformly distributed therein and providing a uniform layer of colour to the outer surface of said article (20).

2. A shaped article (20) according to claim 1, wherein said weatherable polymer film (13) comprises a polymer selected from the group consisting of fluoropolymers, acrylate polymers, urethane polymers, and blends thereof.

3. A shaped article (20) as claimed in claim 1, wherein said molecularly unoriented cast polymer film (13) has reflective pigments uniformly distributed therein.

4. A shaped article (20) according to claim 1, wherein the tear strength of said molecularly unoriented cast polymer film (13) is less than th bond strength of the cast film (13) to said molded polymer substrate (21).

5. A shaped article (20) according to claim 1, wherein said decorative sheet material (10) comprises a bonding layer (14) formed of a polymer different from said cast polymer film (13), said bonding layer (14) being adhered to the inner surface of the cast polymer film (13) and adhered to said molded substrate (21).

6. A shaped article (20) according to claim 5 wherein said bonding layer (14) comprises a polymer coating applied to the inner surface of said cast film (13).

7. A shaped article (20) according to claim 5 wherein said bonding layer (14) comprises a preformed film laminated to the inner surface of said cast film (13).

8. A shaped article (20) as claimed in claim 5, wherein said molded polymer (21) comprises a polyolefin polymer.

9. A shaped article (20) as claimed in claim 8, wherein said weatherable polymer film (13) comprises an alloy of a polyvinylidene fluoride polymer and an acrylic polymer, and wherein said bonding layer (14) comprises a polyvinylchloride polymer.

10. A method of making a shaped article (20) having a decorative outer surface as defined in claim 1, comprising the steps of

a) placing into a mold (11) having a contoured three-dimensional molding surface, a preformed d corative sheet material (10) comprising a substantially molecularly unoriented cast film (13) having pigments uniformly distributed therein,

b) introducing a moldable polymer (12) into said mold (11) on one side of said sheet material (10), and

c) molding said sheet material (10) into a contoured three-dimensional configuration conforming to the molding surface of said mold (11) while molding said polymer (12) to form a shaped article (20) with the decorative film (13) adhered to the outer surface thereof, said film (13) thereby providing a uniform layer of colour to the outer surface of said article.

11. A method according to claim 10, wherein said decorative sheet material (10) also includes a bonding layer (14) formed of a polymer different from said cast film (13), and wherein the decorative sheet material (10) is placed into the mold (11) with said bonding layer (14) oriented inwardly away from the molding surface so as to become adhered to said moldable polymer (12).

12. A method according to claim 10, wherein said moldable polymer (12) is introduced into said mold (11) by injecting said polymer (12) into the mold (11).

13. A method according to claim 10, wherein said cast film (13) is preshaped by subjecting it to heat and vacuum before being placed in said mold (11).

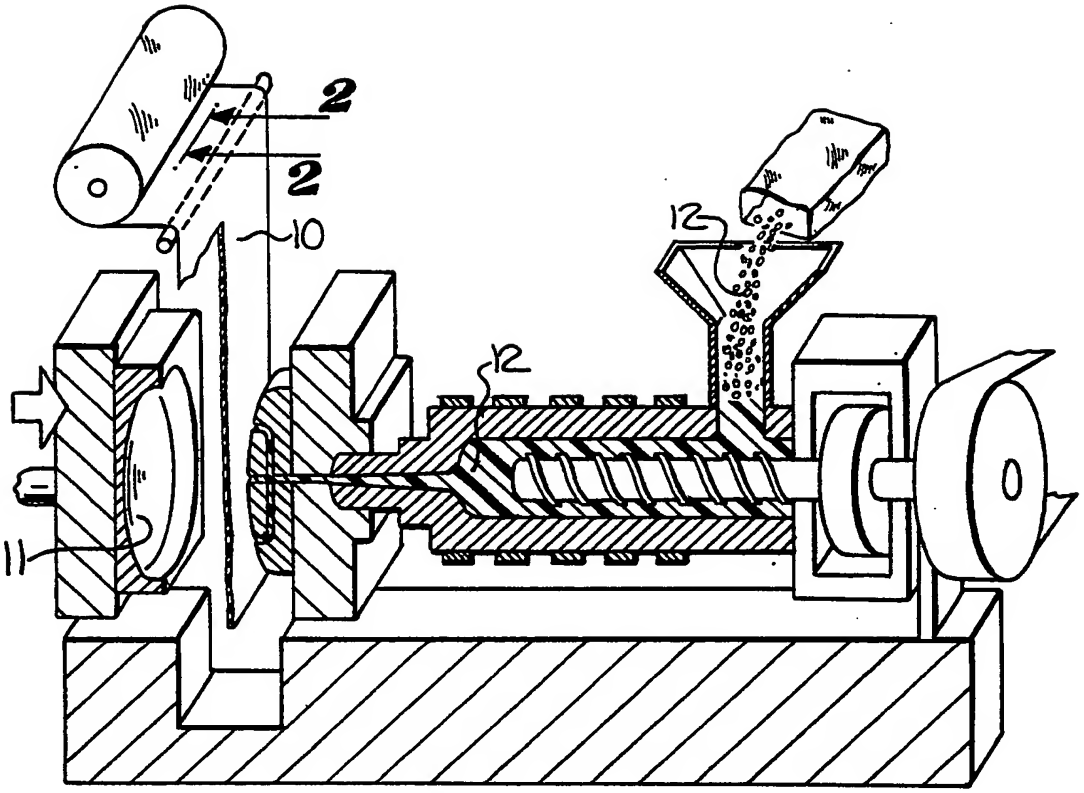

Fig-1

Fig-2

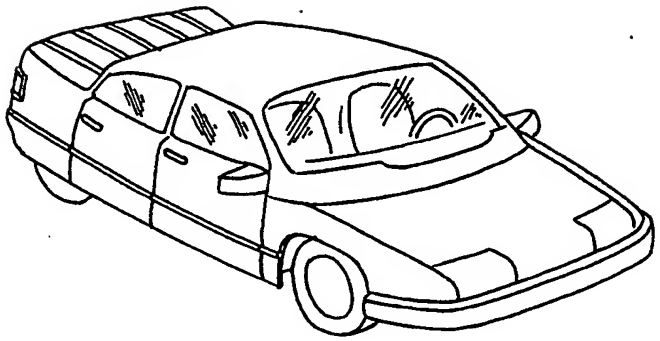

Fig-3

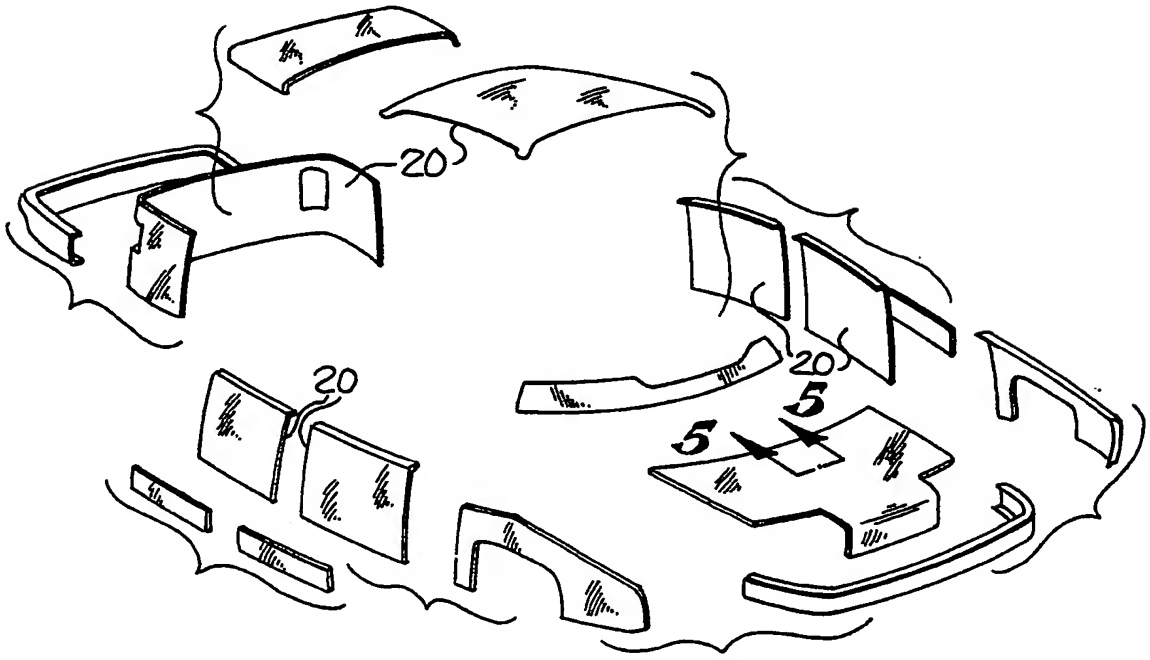

Fig-4

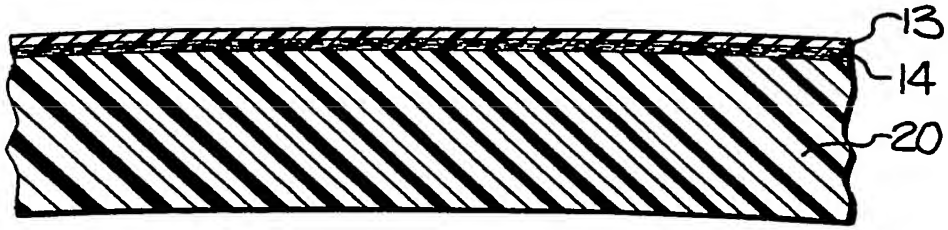

Fig-5